Pneumatic Powered Drone Catcher Gun

Vetri Velmurugan K[1], Maheshwaran C V[2], Balabadra Abhizgn[2], Jagadeesh C[2]

[1]*Assistant Professor, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai*
[2]*Student, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai*

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ABSTRACT - Drones are ubiquitous today, serving various functions like delivery and surveillance. However, their prevalence also poses security risks; they can be misused for unauthorized surveillance or causing disturbances with their noise. To counter this, a system is needed to protect against drones trespassing into private property or restricted areas. Thus, we propose a drone-catching system capable of intercepting drones within a certain range. Our solution involves a drone catcher gun designed not only to shoot but also capture drones intact for further analysis. This allows for the retrieval of valuable evidence without destroying the drone. Powered by a compressed cylinder, the gun operates by releasing high-pressure air through pipes connected to a trigger-operated valve. A specially designed net with four cylindrical ends is deployed to ensnare the target. The net is propelled by cylindrical bullets fired through three hollow barrels to ensure accuracy. The barrels are engineered to enable the net to deploy at a specific angle upon firing. This lightweight and portable system can be mounted on the user's back, facilitating swift deployment to intercept and neutralize unauthorized drones.

***Key Words*:** drone, catcher, pneumatic, compressed, pressure, unauthorized

1. INTRODUCTION

This In 2020, the FAA received over 100 reports monthly regarding unauthorized drone activity. These incidents often involved pilots encountering drones closely, with some drones trailing aircraft from a distance of hundreds of feet to as close as one wingspan away. The notable incident at Gatwick Airport in 2018 disrupted 837 scheduled flights and affected over 130,000 passengers for over 24 hours due to repeated drone sightings. As drone technology advances in battery life, motor efficiency, and the proliferation of drone delivery services, drones are expected to become more sophisticated and accessible to consumers.

To address the issue of nuisance drones, the research team proposes a solution involving a hunter drone equipped with a net launcher and drone detection capabilities. While similar products are in development by other companies, their technology remains proprietary. The team has developed and tested a prototype net launcher and a functional drone tracking gimbal system. This paper evaluates the performance of the prototype net launcher and compares experimental results with simulation data.

While numerous studies have explored net dynamics for space debris capture, limited literature exists on net-based drone capture. The paper draws on related research, such as the design of a net shooting mechanism for larger objects, to inform the development of the present net launcher system.

The focus of this paper is to determine the performance parameters of the net launcher, including open net area and range, through experimental testing. This data will inform the calculation of optimal launch angles and distances for targeting drones, which can be programmed into the on-board computer for automated net deployment based on feedback from a depth camera. The study also contrasts the results of physical experiments with those obtained from simulations conducted using a net deployment simulator.

As the prevalence of drones continues to rise, concerns regarding their unauthorized presence in various areas have prompted the development of homemade tools designed to disable them. This research introduces an innovative homemade anti-drone weapon equipped with four barrels that propel a net using compressed air. The construction process involved repurposing sturdy oxygen bottles capable of withstanding high pressures. The speed at which the valve opens and releases air is crucial for the weapon's functionality, ensuring efficient deployment of the net. Despite weighing approximately 13 pounds, the weapon remains portable enough for operation by a single individual. In summary, the successful performance of the weapon during testing underscores its effectiveness in neutralizing drones, which has left the team satisfied with their accomplishment.

1.1 OBJECTIVES

To design and develop a pneumatic-powered drone catcher gun that can safely and effectively capture unauthorized drones, providing a low-cost and eco-friendly solution for security and law enforcement agencies to mitigate risks posed by drones. The drone catcher gun should be easy to operate, reliable, and capable of launching a lightweight and durable net to entangle the drone and bring it down to the ground in a controlled manner. The objective is to provide a non-lethal solution that can be deployed quickly and efficiently to neutralize the threat posed by unauthorized drones in restricted airspace and other sensitive areas.

1.2 PERSPECTIVES

The applications of this pneumatic drone catcher gun encompass military security, navy security, private property security, parliament security, airport security, and more. Its advantages lie in its ease of use and independence from a power supply. In addition, its rapid deployment capabilities make it an invaluable asset in rapidly evolving security scenarios. Furthermore, its precision targeting and non-lethal capture capabilities enhance its effectiveness in neutralizing aerial threats while minimizing collateral damage. However, it faces limitations including a range constraint, the necessity of carrying a cylinder, and the need for reloading after each shot.

1.3 BLOCK DIAGRAM

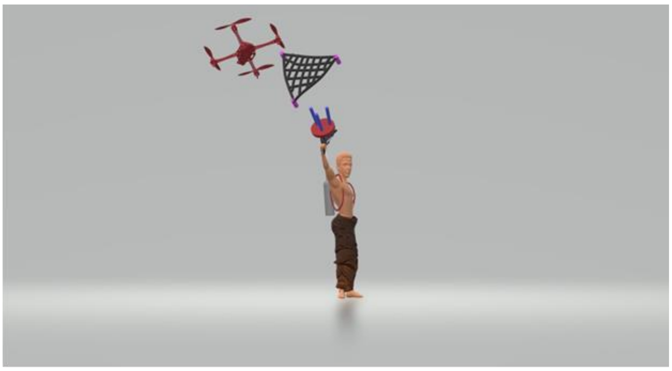

Figure -1.1: Drone Catcher Captures Rogue Drone

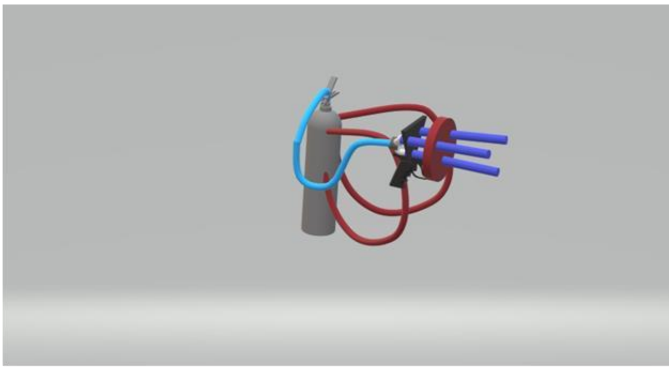

Figure -1.2: Three-barreled Drone Catcher Gun

1.4 ABOUT DRONES

Drones, also known as unmanned aerial vehicles (UAVs), have revolutionized various industries and everyday activities with their versatility and capabilities. These small, remotely operated aircraft have become increasingly popular for tasks ranging from aerial photography and videography to surveillance, agriculture, and even package delivery. Equipped with advanced technology such as cameras, sensors, and GPS systems, drones can navigate through challenging environments and capture high-resolution imagery from unique perspectives. Their agility and maneuverability make them indispensable tools for tasks that are dangerous or inaccessible to humans.

However, the widespread use of drones has raised concerns about privacy, security, and airspace regulations. Unauthorized flights can compromise safety and privacy, prompting governments to establish guidelines for drone operations. Collaboration among stakeholders is essential to ensure drones are integrated safely and effectively into society.

Figure -1.3: Quadcopter Drone

2. LITERATURE REVIEW

A.J. Ikwuakor et al [1] “Design and Development of a Pneumatic Drone Catcher” This paper presents the design and development of a pneumatic powered drone catcher. The authors describe the system's components, including the pneumatic launcher and the net gun, and evaluate the effectiveness of the device in capturing drones.

J. McSheehy et al [2] “Pneumatic Projectile Net Gun for Capturing Small Drones” In this paper, the authors describe the design and testing of a pneumatic projectile net gun for capturing small drones. They evaluate the system's performance in terms of accuracy, velocity, and the ability to capture drones in flight.

S.M. Hall et al [3] “Design and Testing of a Pneumatic-Powered Net Gun for Small Unmanned Aerial Vehicles” This paper presents the design and testing of a pneumatic-powered net gun for small unmanned aerial vehicles (UAVs). The authors evaluate the system's performance in terms of accuracy, velocity, and the ability to capture drones in flight.

J. Kim et al [4] “Design and Development of a Pneumatic Net Launcher for Capturing Small UAVs” In this paper, the authors describe the design and development of a pneumatic net launcher for capturing small UAVs. They evaluate the system's performance in terms of accuracy, velocity, and the ability to capture drones in flight.

W. Cheng et al [5] “A Net-Carrying UAV for Capturing Intruding UAVs” This paper presents a novel approach to capturing drones using a net-carrying UAV. The authors describe the design and testing of the system, which involves launching a net from a UAV to capture an intruding drone.

K. Saengpolsombat et al [6] “Design and Development of a Drone-Catching System Using Pneumatic Piston and Net” This paper presents the design and development of a drone-catching system using a pneumatic piston and net. The authors evaluate the effectiveness of the system in capturing drones in flight and discuss potential applications for the technology.

B. Lee et al [7] “Design and Testing of a Pneumatic-Powered Drone Catcher Gun” In this paper, the authors describe the design and testing of a pneumatic-powered drone catcher gun. They evaluate the system's performance in terms of accuracy, velocity, and the ability to capture drones in flight.

K. Nakamura et al [8] “Development of a Drone Catcher System Using Pneumatic Piston and Net” This paper presents the development of a drone catcher system using a pneumatic piston and net. The authors evaluate the effectiveness of the system in capturing drones in flight and discuss potential applications for the technology.

3. METHODOLOGY

Figure -3.1: Methodology

3.1 RESEARCH AND LITERATURE REVIEW

We conducted an extensive review of the existing literature on drone catcher technology, with a focus on the different types of drone catchers available in the market and their advantages and disadvantages. This research helped us to identify the most suitable type of drone catcher for our project.

3.2 DESIGN AND DEVELOPMENT

Based on the literature review, we designed and developed a prototype of the pneumatic powered drone catcher gun. We used SolidWorks software for the 3D modeling of the gun and tested the design for its structural integrity and feasibility.

3.3 TESTING AND EVALUATION

After the successful design and development of the prototype, we conducted multiple rounds of testing to evaluate the performance of the pneumatic powered drone catcher gun. We tested the accuracy, speed, and efficiency of the gun under different environmental conditions and refined the design accordingly.

3.4 FINAL IMPLEMENTATION AND RESULTS

Finally, we implemented the pneumatic powered drone catcher gun and tested it in real-world scenarios. We recorded the results of each test and evaluated the performance of the gun based on the predetermined metrics. We also analyzed the limitations of the gun and provided recommendations for future improvements.

4. DESIGN AND DEVELOPMENT

The 3D design has been meticulously crafted using SolidWorks software, a widely-used computer-aided design (CAD) program renowned for its robust features and capabilities. Utilizing SolidWorks' intuitive interface and robust tools, our team brings concepts to life with precision and efficiency, ensuring every component is intricately detailed and seamlessly integrated within the design.

In addition to 3D modeling, rigorous testing ensures designs meet quality standards. Using SolidWorks' simulation tools, we analyze structural integrity, thermal dynamics, and fluid flow, among others. This iterative approach ensures products exceed expectations in performance and reliability. The designs listed below showcase the meticulous attention to detail and precision inherent in SolidWorks:

4.1 FRONT VIEW

Figure -4.1: Front View of Drone Catcher

4.2 BACK VIEW

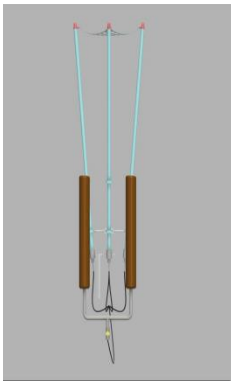

Figure -4.2: Back View of Drone Catcher

4.3 TOP VIEW

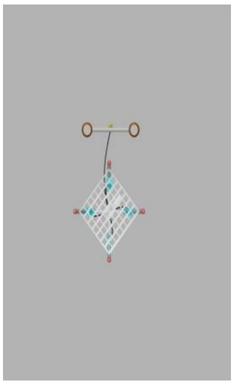

Figure -4.3: Top View of Drone Catcher

4.4 BOTTOM VIEW

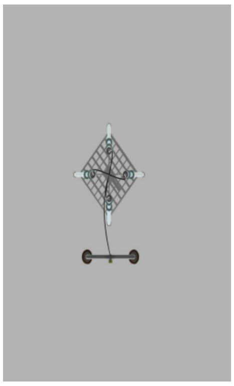

Figure -4.4: Bottom View of Drone Catcher

4.5 LEFT VIEW

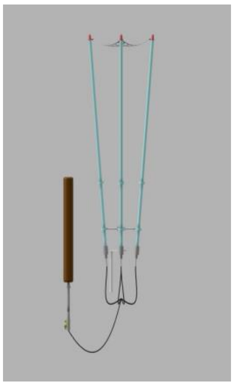

Figure -4.5: Left View of Drone Catcher

4.6 RIGHT VIEW

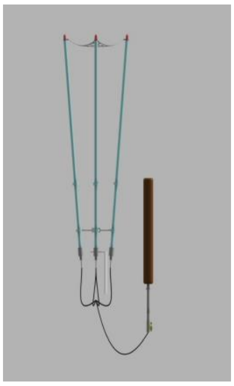

Figure -4.6: Right View of Drone Catcher

5. COMPONENTS AND WORKING

5.1 COMPONENTS

5.1.1 PNEUMATIC PRESSURE TANK

A pneumatic pressure tank is a form of pressure vessel designed to contain compressed air or gas, serving as a power source for pneumatic tools and machinery. Typically found in industrial environments, it is essential for applications requiring compressed air, such as machinery operation and pneumatic system control. These tanks vary in size and structure and are typically constructed from materials like steel or aluminum.

Figure -5.1: Pneumatic Pressure Tank

5.1.2 STAINLESS STEEL PIPES

Stainless steel pipes are used as bullet thrower units, pressurized air flows through the pipeline to throw the bullet.

Figure -5.2: Stainless Steel Pipes

5.1.3 NON-RETURN VALVE (NRV)

A pneumatic non-return valve functions as a valve permitting air flow in one direction while inhibiting it from moving in the opposite direction. It's a prevalent component in pneumatic systems, ensuring proper air direction and safeguarding against system damage. Engineered to shut automatically upon encountering back pressure, it effectively blocks reverse air flow.

Figure -5.3: Non-Return Valve (NRV)

5.1.4 RELEASE VALVE

A pneumatic release valve is a device used to control the flow of compressed air in a pneumatic system. It is designed to release excess pressure in the system when it reaches a predetermined level. The valve helps to maintain safe and stable operation of the pneumatic system.

Figure -5.4: Release Valve

5.1.5 CIRCULAR HOLDER

A circular holder is used to hold the trigger pipes and it is fixed to the holding unit.A circular holder is used to hold the trigger pipes and it is fixed to the holding unit.

Figure -5.5: Circular Holder

5.1.6 BULLET BARREL EXTENSION UNIT

The Unit shown in the below picture is used to change the angle of the pipeline into a wider angle to catch the drone which is bigger in size.

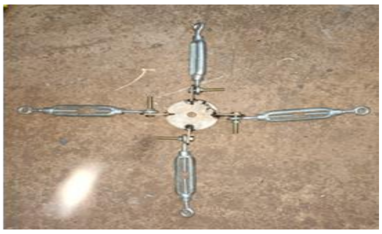

Figure -5.6: Bullet Barrel Extension Unit

5.1.7 NET PROJECTILE

A net projectile for a drone catcher is a specialized tool designed to capture unmanned aerial vehicles (UAVs) using a net. It is fired from a launcher at the target drone, which gets entangled in the net and is then safely brought down to the ground. This technology is used to counter rogue drones in sensitive areas.

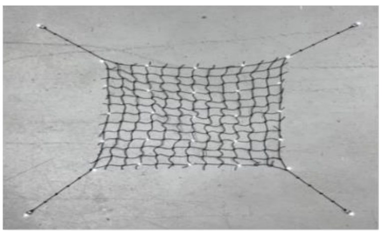

Figure -5.7: Net Projectile

5.2 WORKING

A pneumatic-powered drone catcher gun is a device designed to capture rogue drones in a safe and efficient manner. The device is powered by compressed air, which provides a powerful burst of energy that can propel a net or other capture mechanism towards the drone.

The working of this device involves several key components. Firstly, compressed air is stored in a tank, which is connected to a valve that controls the release of the air. When the trigger is pulled, the valve opens and the compressed air is released, propelling the capture mechanism towards the target drone.

The capture mechanism can take various forms, such as a net, a hook, or a sticky adhesive surface. Once the mechanism makes contact with the drone, it entangles it, making it impossible for the drone to fly away. The captured drone can then be safely retrieved without any risk of damage or injury.

The design of the device can vary depending on the specific requirements of the user. For example, the size of the tank and the pressure of the air can be adjusted to accommodate different types of drones. Similarly, the capture mechanism can be customized to suit different scenarios.

To ensure the safe and effective operation of the device, it is important to follow proper safety procedures and guidelines. This includes wearing appropriate protective gear, ensuring proper training and certification, and following all relevant laws and regulations.

Overall, a pneumatic-powered drone catcher gun is a highly effective tool for capturing rogue drones. Its ability to safely and efficiently capture drones without causing any harm or damage makes it a valuable asset for security and law enforcement agencies.

6. EXPERIMENTAL SETUP

6.1 TESTING CONFIGURATION

The objective of the net launcher design is to deploy a tethered net aimed at a target drone for capture and incapacitation. It's imperative for the net launcher to maintain a lightweight construction suitable for drone portability. Compressed air functions as the launching mechanism for the net, stored in a container and released onto four weighted masses (bullets) affixed to each corner of the net. A manually operated valve is indispensable for releasing the air, crucial for operation. The launcher features a custom-designed barrel to direct air pressure to the bullets and to store both the net and bullets. The current design is depicted in the accompanying figure,

Figure -6.1: Experimental Setup of Drone Catcher Gun

6.2 CALCULATION

1. **Calculation of Required Force:** To calculate the force required to capture a drone, we first determine the weight of the heaviest drone that the gun is intended to capture. For example, let's assume that the heaviest drone weighs 5 kg.

2. **Calculation of Pressure:** Based on the weight of the drone, we then calculate the pressure required to capture the drone. We determine that a pressure of 80 PSI is sufficient for capturing a drone weighing up to 5 kg.

3. **Calculation of Air Volume:** To calculate the air volume required to achieve the desired pressure, we use the following formula:

Air Volume = (Pressure x Cylinder Volume) / Atmospheric Pressure

Assuming the cylinder volume is 10 cubic inches and atmospheric pressure is 14.7 PSI, the calculation would be:

Air Volume = (80 PSI x 10 cubic inches) / 14.7 PSI = 54.4 cubic inches

4. **Calculation of Valve Size:** Finally, we calculate the valve size required to achieve the desired air flow rate. We use the following formula:

Valve Size = (Air Volume x 0.134) / Time

Assuming a time of 1 second and using the air volume calculated in step 3, the calculation would be:

Valve Size = (54.4 cubic inches x 0.134) / 1 second = 7.3 cubic inches per second

These calculations can be used to determine the appropriate specifications for the pneumatic-powered drone catcher gun, ensuring that it is capable of capturing drones of varying weights and sizes.

7. EXPERIMENTAL RESULTS

Experiments were carried out in a controlled lab setting to assess the effectiveness of the devised launch system and to gather data for comparison with simulated outcomes.

During all trial launches, the air tank was pressurized to approximately 30-50 PSI using a bike pump. The valves utilized have a rating of 90-100 PSI, but due to flaws in product quality, it was discovered that these valves tend to develop leaks when pressure exceeds 50 PSI. Furthermore, it was crucial for the launched net to remain within the view of the cameras during the launch for data collection purposes, and around 50 PSI was determined as the maximum pressure to maintain control over the net's trajectory. Bullets were manually inserted into the launcher barrel, and the netting was packed in as evenly and symmetrically as possible, mirroring the setup depicted in Figure. Following the completion and recording of all calibration launches, data from each test was analyzed. A visual representation illustrating the dynamics of the net throughout a test launch at a 22° angle and 40 PSI was generated.

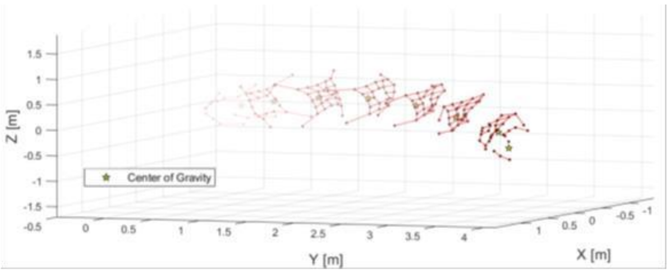

Figure -7.1: Tests launch data - Plotted nodes

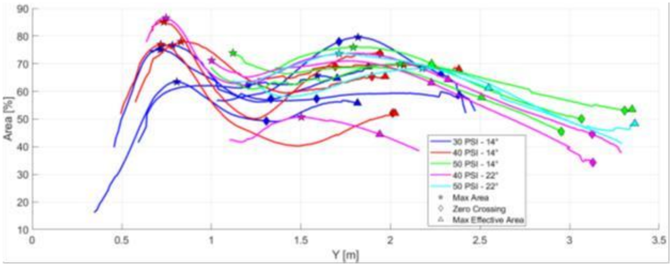

Figure -7.2: All Trails - Net opened area vs. Distance

Tuning of vertical launch simulations was performed in attempts to recreate the experimental vertical net launch as well as possible. The following parameters needed to be defined, where X indicates values that needed to be tuned throughout tests:

- *L* = 0.6096 [m] (Or 24 in=2 ft. Length of a side of the net)
- *n* = X (number of side nodes)
- SA = 0.0440 [m2] (frontal surface area of the net)
- *mnet* = 0.0339 [kg] (mass of net)
- *mbullet = 0.0097 [kg] (mass of a single corner bullet including weight of tracking marker)*
- Vx0,y0,Vz0 = X [m/s] (initial velocity for the bullets)
- *k* = X [N/m] (stiffness)

8. CONCLUSION

The development of the Pneumatic Powered Drone Catcher Gun has proven to be a promising solution to the increasing concern over unauthorized drone activity. This project aimed to create a safe and effective means of capturing drones, and the resulting product has demonstrated its capability to achieve this goal.

The successful implementation of this project involved a thorough understanding of the design requirements, mechanics, and safety protocols. Through experimentation and analysis, the team was able to optimize the design for efficiency, accuracy, and safety. The final product is capable of launching a net to safely ensnare a drone mid-flight, using a pneumatic system powered by compressed air.

While further improvements and testing could be done, the Pneumatic Powered Drone Catcher Gun has the potential to be a valuable tool for law enforcement and security personnel in the ongoing fight against unauthorized drone activity. As drone usage continues to rise, the development of effective countermeasures becomes increasingly important. The team hopes that this project can contribute to the growing body of research in this area and inspire further innovation in drone technology.

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